Entertainment Technology and Military Virtual Environments

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...Knowing how to create compelling experiences; do low-cost, high-performance computing; support large-scale network simulations; build graphics-modeling software is (or will be) [the entertainment community] stock and trade. In these areas not only will it be futile for the Army to try to compete, but a waste of energy and resources. Bran Ferren [1]

Introduction

Bran Ferren makes a compelling argument that the Entertainment Industry is driving the technology advances needed for military virtual reality systems. Moreover, the military virtual environment community may actually be falling behind its civilian counterparts by ignoring the rapid changes going on in entertainment computing. These advances include low cost computer graphics, agent technology, and the use of 3D audio.

In this paper we will explore some of the reasons how and why the Entertainment Industry is advancing the state of virtual reality (VR). We will also look at the current problems of military simulation, particularly its lack of story and emotion. Finally, this paper examines how the US Army is trying to address these issues with the establishment of the Institute for Creative Technology (ICT).

The Entertainment Industry

The Entertainment Industry has in many ways grown far beyond its military counterpart in influence, capabilities and investments. For example, Microsoft alone expects to increase R&D spending next year by 23 percent, to $3.8 billion — compared to the US Army's $ 1.2 billion science and technology budget. The Interactive Digital Software Association estimates that in 1998, interactive entertainment businesses invested approximately $2 billion in new technology R&D, with an increase of more than 20 percent. [2] This far outweighs current US Army research and development for training and simulation technology.

Moreover, the advances in the industry cannot be ignored. Witness the rapid pace of development of the graphics systems for game consoles and personal computers — almost double performance every nine months [3]. Compare this with the relatively slow gains in "high-end" graphics platforms being used for the military.

According to Richard Weinberg at the University of Southern California's School of Cinema-Television, Sony's upcoming PlayStation 2 is an example of a consumer-grade advanced technology gaming platform that could revolutionize both the world of home gaming as well as interactive training for the Army. The PS2 is expected to have 34 times the power of the current leading game system, the Sony PlayStation, and more than twice the graphics performance of SGI's (formerly Silicon Graphics) high-end visualization system, the Infinite Reality 2. Here is what *Game Informer Magazine* (May 1999) says about the upcoming Playstation 2: "PlayStation 2 could be a glimpse at Hollywood of the 21st Century. Developers with this kind of power in their hands could theoretically create real-world environments, with living breathing characters all affected by real-world physical attributes such as gravity, friction and mass. Plus, PS2 can accurately simulate different materials such as water, wood, metal, and gas — real worlds that look like real worlds. Full motion video that's not full motion video, but real-time game play with speaking characters, fluid motions, and facial expressions."

Playstation 2Graphics Synthesizer – Features and General Specifications:

- GS Core: Parallel Rendering Processor with embedded DRAM
- Clock Frequency: 150 MHz
- No. of Pixel Engines: 16 (in Parallel)
- Embedded DRAM: 4 MB of multi-port DRAM (Synced at 150MHz)
- Total Memory Bandwidth: 48 gigabytes per second
- Combined Internal Data Bus Bandwidth: 2,560 bit
- Read: 1,024 bit
- Write: 1,024 bit
- Texture: 512 bit
- Display Color Depth: 32 bit (RGBA: 8 bits each)
- Z Buffering: 32 bit
- Rendering Functions: Texture Mapping, Bump Mapping, Fogging, Alpha Blending, Bi- and Tri-Linear Filtering, MIPMAP, Anti-aliasing, Multi-pass Rendering

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Rendering Performance:

- Pixel Fill Rate: 2.4 giga pixel per second (with Z buffer and Alphablend enabled), 1.2
- giga pixel per second (with Z buffer, Alpha and Texture)
- Particle Drawing Rate: 150 million/sec
- Polygon Drawing Rate: 75 million/sec (small polygon), 50 million/sec (48 pixel quad with Z and A), 30 million/sec (50 pixel triangle with Z and A), 25 million/sec (48 pixel quad with Z, A and T)
- Sprite Drawing Rate: 18.75 million (8 × 8 pixels)

Digital Output:

- NTSC/PAL
- Digital TV (DTV)
- VESA (maximum 1280 × 1024 pixels)

Other technical trends that will likely shape the military training world will be digital cinema, the convergence of television with the World Wide Web, and the continued rapid growth of multiplayer Internet 3D games such as Sony's *Everquest*.

Weinberg also notes that, from a content perspective, the computer game industry has considerable expertise in games relevant to aspects of military training, with significant interest in war games, simulations, and military-like shooter games. For example, TalonSoft's *The Operational Art of War II* is expected to cover the Vietnam War, Arab-Israeli wars, the Iran-Iraq conflict, and Operation Desert Storm at the operational command level, as well as several hypothetical conflict scenarios ranging from India/Pakistan to a new Korean conflict. *Extreme Tactics*, *Warbreeds*, and *WarZone 2100* are but a few examples of the war/strategy/shooter-style games available. According to the May 15, 1999 issue of *Games Business*, PC games by genre, ranked by unit share from April 1998-March 1999 were comprised of Strategy 21.8%, Simulation 13.4%, Adventure/role playing 12.1% and Action 11.4%. [2]

Even traditional flight simulation companies are taking advantage of the emergence of commercial game software for training. For example, Flight Safety International re-markets a version of Microsoft Flight Simulator and the Navy is experimenting with the game for new pilot training.

What's Wrong with Military VR?

Until recently, the military has led the way in developing advanced virtual environments. We know the importance of experiential learning through the development and use of the National Training Center, Conduct of Fire Trainers, Simnet, and flight simulators. The vision of the military VR community has been to develop realistic virtual environments to support training, mission rehearsal, concept exploration and engineering design.

However, military simulations currently fall short of enabling this vision of realism for a multitude of reasons. First, the necessary technology does not yet exist, and must be created. Our ability to immerse participants is quite limited. For example, with respect to physical immersion, it is currently possible to provide good auditory, moderate visual, and primitive tactile/haptics while essentially no olfactory or gustatory immersion is possible. The ability to track full body motion, gesture and expression is still nascent while virtual mobility is limited to primitive two-dimensional approaches.

What technologies do exist for physical immersion tend to be neither portable nor wireless. They also have interoperability problems, fail to scale well to large numbers of entities and have latency problems when it comes to closely coupled interactions over long distances. Defining (modeling), organizing and distributing multimedia content also can be a problem.

Second, the stories and characters used in military simulations are skeletal and rudimentary. A typical story consists of a background briefing plus an event list. A typical character is defined in terms of a role and a set of scripted behaviors. Some degree of intellectual immersion, to the extent of triggering some of the same key decision making tasks that would occur in the real world, is possible with such minimal story and character definitions. However, rich story and engaging characters can more fully engross the participant and provide a more appropriate context for intellectual activity. (Note that for peacekeeping training the US Army often hires actors for live exercises at its Combat Training Centers.)

Lack of rich story and character also impairs emotional immersion, as abstractions do not generally induce intense emotions. Because emotions are powerful motivators, and can lead to significant shifts in both how the world is interpreted and how decisions are made — in the extreme, it can be a matter of decision making in a life-or-death situation — this lack of emotional immersion is a major gap in making realistic simulations. Emotional immersion is a particular strength of the entertainment industry.

Third, the full set of necessary people to solve these problems has been incomplete. Technical personnel working with domain experts currently build military simulations. This collaboration is critical, but creative personnel — such as writers and cinematographers — need to be added to the mix. The further advantages of such a combination are that technical advances can open up new creative realms, creative needs can drive new research, and creative techniques can mask limitations in technology.

[2]Weinberg was a key member in the development of the ICT proposal.

Recognition

Early in 1999, US Army leaders recognized a need for a major transformation of our forces and the limitations of our current simulation technologies. Furthermore, this transformation required the ability to develop new training and simulation systems for future conflicts that leveraged the capabilities of both the entertainment industry and academia.

The US Army and Department of Defense selected the University of Southern California (USC) as a strategic partner in the development of the Institute for Creative Technologies (ICT) because of its unique confluence of scientific capabilities and Entertainment Industry relationships necessary for leadership in simulation.

The prime objective, as reaffirmed by Dr. Michael Andrews, Deputy Assistant Secretary of the Army for Research and Technology, was to build a special partnership with the entertainment industry and academia. Furthermore it was to advance the state of the Army's technology and transition it quickly to programs such as the Future Combat System.

A University Affiliated Research Center (UARC) is a strategic relationship, requiring both breadth and depth in capabilities matched with industry partnership to achieve major advancements in science and technology.

This model of research is not new. For example The National Automotive Center (NAC) serves as the Army's focal point for the development of dual-needs/dual-use automotive technologies and their application to military ground vehicles. The NAC identifies the common needs of the Defense Department, automotive industry and academia for the purpose of collaborative research and development.

Part of USC's uniqueness arises from its location in Los Angeles, at the hub of both the entertainment and aerospace industries; part arises from its standing as a leading private research university; and part arises from the capabilities and stature of its component units, and the working relationships they have developed with industry.

USC's top-ranked School of Cinema-Television grew up with the entertainment industry and continues to maintain uniquely close ties with it. USC's School of Engineering is ranked 12th in the nation. Its Information Sciences Institute is home to leading academic research groups in networking and artificial intelligence. USC's top-ten (and in some rankings, top-five) ranked Annenberg School for Communication leverages off of the Los Angeles area's varied strengths in new technology, telecommunications, film, television, radio, newspapers and magazines, and policy and research organizations.

The Institute for Creative Technology

USC established ICT under the auspices of the US Army Simulation, Training, and Instrumentation Command (STRICOM) to focus on developing the art and technology for synthetic experiences that are so compelling participants will react as if they are real. That is, ICT will bring *verisimilitude* — the quality or state of appearing to be true — to synthetic experiences. This will produce a revolution in how the military trains and how it rehearses for upcoming missions; just to name two quite specific, but highly critical, military needs. However, more generally, it will provide a quantum leap in helping the Army prepare for the world, soldier, organization, weaponry, and mission of the future. Beyond the military, ICT will also advance a compelling new medium for (at least) entertainment, education, arts, and travel.

From the start, ICT leverages heavily off of this dual-use nature by actively engaging the Entertainment Industry (comprising film, TV, interactive gaming, etc.) and possibly other industries later. ICT will serve as a means for the military to learn about, and benefit from, the technologies that are being developed in the Entertainment Industry, and for transferring technologies from the Entertainment Industry into the military. ICT will also work with creative talent from the Entertainment Industry in order to adapt their concepts of story and character to increasing the degree of immersion experienced by participants in synthetic experiences, and to improving the utility of the outcomes of these experiences.

ICT will pursue a combination of basic and applied research (plus some educational activities). Basic research will cover six thrusts crucial to the kind of verisimilitude that is the institute's mission [4]:

1. Immersion — Providing compellingly realistic experiences
2. Networking and Databases — Organizing, storing and distributing content
3. Story — Providing compelling interactive narratives that propel experiences
4. Characters — Replacing human participants with automated ones
5. Setup — Authoring and initializing environments, models and experiences
6. Direction — Monitoring, directing, and understanding experiences

Applied research will be organized around a small number of long-term themes; for example, simulating futuristic style forces. Within each theme, a set of key projects will be identified, along with an integration architecture that will eventually bring them all together in a single system covering the theme. Projects will be pursued via sequences of prototypes of increasing functionality and level of integration. The Army and the Entertainment Industry will be actively involved at each

step in helping to ensure that what is done meets their needs.

Key elements associated with USC's array of relevant existing capabilities include:

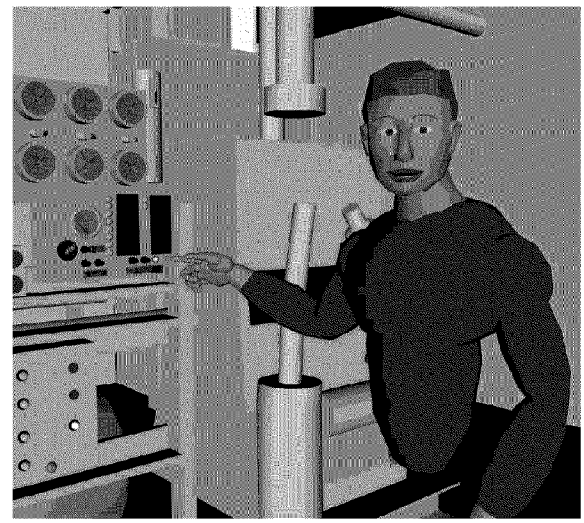
- The Entertainment Technology Center, (ETC) which is a research and development project of the School of Cinema-Television. ETC's mission is to discover, research, develop and accelerate entertainment technology. Steven Spielberg and George Lucas sit on the ETC board.
- The Annenberg Center for Communication that advances communication and information technologies through interdisciplinary research and outreach.
- The Integrated Media Systems Center, (IMSC), a National Science Foundation (NSF) established center providing multi-media technologies. USC successfully outbid 117 other university competitors in response to the 1996 NSF national competition for an integrated media center.
- The Information Sciences Institute, which combines world class research and development across a broad range of computer science and engineering with a strong relationship with the Department of Defense.

ICT Vision

The vision for the ICT is to develop the art and technology for synthetic experiences that are so compelling participants will react as if they are real. Participants will be fully immersed physically, intellectually, and emotionally. They will be capable of full three-dimensional mobility. Their behavior will be propelled through engrossing stories stocked with engaging characters that may be either automated or manned — the high quality of the automated characters along with the provision of plug compatibility will make it impossible to distinguish. They will interact with the experiences as if they are real. In short, the ICT will provide a new meaning for "high fidelity": *verisimilitude*.

Imagine the soldier of the not so distant future. It is Sunday and he is at home in Los Angeles. He and his best friend in Hong Kong are relaxing by immersing themselves in the nostalgic world of the 1990s. They are founding an Internet startup company during the heyday of the speculative bubble, learning to deal with venture capitalists, trying to fend off large predatory rivals, and ultimately trying to steer their new company towards a successful Initial Public Offering. However, just when the story is getting really engrossing, a high priority videomessage arrives from his commanding officer with the news that he will be shipping out within a few days, along with the five thousand or so other members of his Strike Force.

The mission will be to help keep the peace in the latest global hot spot, but there are not yet any details concerning his unit's specific mission or the volatile situation that currently exists on the ground there. He also knows nothing about the country's history, culture or language. Fortunately he has a long flight ahead of him, and the Army is ready for him.



STEVE is an intelligent tutor developed by USC/ISI for the Office of Naval Research. [6]

He begins the flight with a brief on-line course covering the history and culture of the region. A virtual tutor helps him make the best possible use of the very limited time he has available. (See figure). He then dons his personal immersion system and walks into a simulated market in the capital city, where a helpful (computer generated) shopkeeper introduces him to the basic aspects of the language along with the range of interpersonal interaction styles — both positive and negative — common to the culture.

Next, he is briefed by his commanding officer on his unit's mission — to keep innocent civilians from being hurt in factional violence while preventing, as much as possible, new flare ups among the factions. By sharing an immersive space with his commander and the rest of his unit — even though in reality they are physically dispersed across several transport aircraft — he is able to join them for a quick tour of their area of responsibility, followed by a session in which they are able to familiarize themselves with the uniforms and weapons used by the various factions. He can pick up the uniforms and examine them as well as see them on various models. He can try out the weapons himself, as well as pull up specs and performance numbers on them. At all times he can discuss what he sees and does with his commander and the other members of his unit.

During his final few hours he is immersed in a sample mission. The sights, sounds and smells of the city immediately bombard him. There are people everywhere going about their lives as best they can. He's a bit scared and hesitant at first, but fortunately the rest of his unit is there in the street with him. There's a second unit

nearby, however he is unaware that they — along with all of the citizens with whom he is interacting — are computer-generated characters.

He is in a large central plaza in the city. A bazaar is located in one part of the plaza and throngs of people are milling about bartering for various goods. The plaza is ringed by several government buildings and at the far end there is a large church. The scene is a rich and confusing tapestry of life — our soldier struggles to remember the identifying features of the various factions as he attempts to make sense of the scene. Suddenly, near the church, a large disruption occurs and reports ring out, echoing off the buildings. What is going on? Is one of the rebel factions trying to attack the government? Rifles at the ready, he and other members of his squad rush toward the disturbance, where they confront — a wedding party leaving the church and a group of celebrants setting off large firecrackers.

Switching the safety back on, he shoulders his rifle and breathes a sigh of relief while a computer generated tutor emphasizes the need to assess the situation before taking action and points out that in this culture celebrations are often accompanied by fireworks which can be mistaken for gunfire. This kind of immediate feedback is enabled through the use of computer agents as tutors. Because it is provided in context, it can be much more effective than an after action review, where there may be a substantial delay between the exercise and the review.[3]

This scenario was orchestrated by the Director, another computer agent that directs the behavior of the other agents in the simulation and the environment. By exercising control of these elements, the Director ensures that the exercise follows the intended story line so that the intended training goals can be achieved. In this case, this scenario was intended to create a situation in which the soldier would be confronted with an ambiguous but potentially threatening situation where it would be necessary to decide whether or not to act — and where the wrong decision would have disastrous consequences.

Although the soldier in the exercise is free to make choices, the Director manipulates the simulation so that eventually he is forced to confront the intended dilemma, thereby achieving the pedagogical goals for the simulation. For example, if the soldier and his squad had not noticed the initial disturbance, the wedding celebration would have become louder and more boisterous, until it could not be ignored. Furthermore, the squad's failure to recognize the disturbance in its early stages would be an issue that the tutor would cover during its *in situ* review of the exercise.

This is just one of many possible examples of the kind of experience that ICT will make possible and, in fact, commonplace. Verisimilitude of this sort will require combining the art of (interactive) storytelling with the art and technology of transforming these stories into compelling interactive experiences. It inherently involves collaboration between the kinds of creative and technical experts found in the entertainment industry and the kinds of researchers and system builders found in the academic, industrial and military R&D communities. Fortunately, all of these necessary partners are either already present at USC or linked closely with it.

We expect that by creating a true synthesis of art and technology[4] and of the capabilities of the entertainment industry and the R&D community — all in service of verisimilitude — military training and mission rehearsal will be revolutionized by making it more effective in terms of cost, time, the types of experiences that can be trained or rehearsed, and the quality of the result. It will also provide a new medium for entertainment, enabling both individuals and groups to be fully immersed and engaged in compelling experiences from their homes, or wherever they happen to be located.

Beyond entertainment, verisimilitude will also provide new media for (at least) both immersive distance learning and the arts (particularly the performing arts). It could also even support a new mode of virtual travel; providing immersive presence in a remote location, and augmenting the local populace (with whom direct interaction may not be possible) with synthetic characters with whom interaction is possible.

Conclusion

The computer and Internet revolutions have substantially changed the direction of entertainment from delivery in a mass medium such as television to a mass customized experience via the Web and PC. However, the art of entertainment still requires stories, characters and direction to make the experience meaningful and enjoyable.

The US Army faces the same challenge of adapting to the changes brought about through the mass marketing of supercomputing (e.g. Playstation 2), low-cost graphics, and the higher expectations of technically savvy soldiers.

Moreover, a more fundamental need is to represent new kinds of problems such as urban conflict, operations other than war, and information operations that cannot be simulated well in military virtual environments today. As the vignette presented above demonstrated, there is an urgent requirement to represent the human dimensions of war and conflict to provide training for the truly difficult decision-making problems our soldiers

[3] This vignette was partly developed by William Swartout, the Technical Director for ICT.

[4] Providing what Richard Lindheim, the Executive Director of ICT, has referred to as *Show Technology* as a complement to the more common combination of art and business as *Show Business*.

must face. NATO's experience in Kosovo is now a common one for countries such as the United Kingdom (e.g. Northern Ireland).

The establishment of the Institute for Creative Technologies is just one of many steps needed to providing the essence of verisimilitude into training and virtual reality systems. The US Army will explore all avenues of entertainment technology to keep pace with the challenges presented to us, whether in application to distributed learning or embedded training systems. Ultimately, we want to prepare our soldiers for the future by experiencing it.

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Biographies

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